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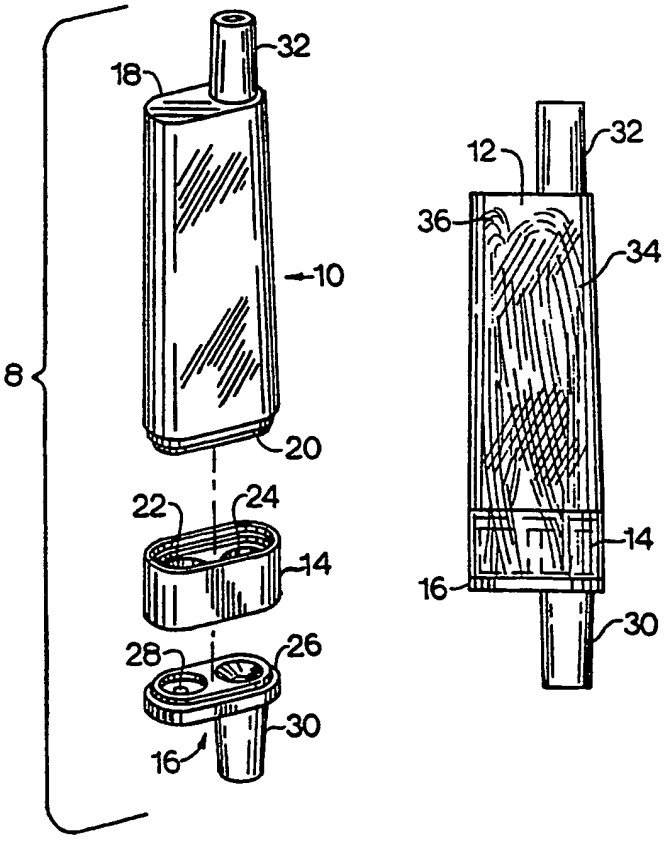
(57) Abstract

Disclosed is gas separating and venting filter (10) including a housing (8) having walls (18) defining an interior chamber (12) with a fluid inlet (32), a liquid outlet (30), and a gas outlet (28) from the interior chamber. Within the chamber are a plurality of hollow microporous fibers of a hydrophilic nature (34), with the interior of the fibers being in communication with the liquid outlet. Furthermore, there are a plurality of microporous hollow fibers of a hydrophobic nature (36) disposed within the interior chamber, with the interior of the hollow fibers being in communication with the gas outlet.



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GAS SEPARATING AND VENTING FILTER AND METHOD OF MAKING SAME

BACKGROUND OF THE INVENTION

The present invention relates generally to fluid filters which separate gas from liquid in a fluid stream and vent the gas and to a method of making same. More particularly, the present invention relates to such filters utilizing hollow fibers for separating and venting gas and for filtering liquids.

Fluid filters which utilize porous membranes or other filter media for filtering liquids, which also separate gas from liquid and vent the gas have been used in a variety of situations. One important use for such filters is in filtering parenteral solution or other fluid, as the fluid is administered to a living subject, usually human. In the administration of such fluids, in addition to filtering out particulate matter and potentially harmful micro-organisms, it is preferred that any gas suspended or entrained in the fluid also be removed so as to eliminate any hazard of embolism from air or gas reaching the patient.

Filters which utilize both hydrophobic and hydrophilic membranes are well known. Present filters utilizing one or more hollow fibers are also known. However, these filters typically have a number of drawbacks. A common shortcoming with these filters is that the filter must be maintained in an upright position in order to operate effectively in venting gas. In other filters, the surface of the filtering membrane is small, thereby having limited filtering capacity. The cost factor also plays a considerable role, since such filters can or must, in medical applications, be used only once. Many current filters are relatively expensive to manufacture, which adds significantly to the total product cost.

U.S. Patent No. 4,568,366, for example, discloses a medical fluid filter which utilizes hydrophilic fibers, and unlike the present invention, a hydrophobic membrane positioned at the top of the filter. This filter is position sensitive and must be maintained in an upright position in order for separated gas to be vented from the housing. Build-up of gas may result in partial blockage of the hydrophilic fibers and lead to reduced flow rates to the patient.

European Patent Application No. 0086028 discloses a filter for water purification which uses both hydrophobic and hydrophilic fibers. However, unlike the present invention, the two different fibers are not contained in the same housing. The hydrophobic fibers are encased within a housing mounted on top of the liquid filtering housing, thereby making the effectiveness of the filter dependent upon its maintenance in an upright position. As such, this filter also requires two separate housings, thereby increasing manufacturing costs.

U.S. Patent No. 4,636,307 discloses a water purification filter which utilizes both hydrophilic and hydrophobic fibers. Unlike the present invention, the device disclosed in this patent does not separate and vent gas, but intentionally reentrains the gas into the liquid after it is filtered. Specifically, after the water has passed through the hydrophilic fibers and been filtered of impurities, the filtered water and the gas, which passed through the hydrophobic filters, exit the filter housing through the same outlet. This is not atypical. Water purification filters are seldom concerned with re-entrainment of the gas in the liquid after filtering. Indeed, a certain level of dissolved air enhances the taste of the water.

Accordingly, it is a general object of the present invention to provide a gas separating and venting filter which does not suffer from the drawbacks described above.

Another object is to provide a gas separating and venting filter which is substantially less expensive to manufacture than existing filters.

These and other objects of the present invention are set forth in the following detailed description of the illustrated embodiments of the present invention.

SUMMARY OF THE INVENTION

The present invention is directed to a liquid filter which also separates and vents gas from the liquid. In accordance with the present invention, a filter for separating and venting gas from liquid is defined by a housing having an interior chamber with a fluid inlet into the interior chamber and a gas outlet from the interior chamber. Located within the housing are two sets of microporous hollow fibers. One set of hollow fibers is of a hydrophilic nature and the interiors of the fibers are in communication with the liquid outlet. The other set of hollow fibers is of a hydrophobic nature and the interiors of the fibers are in communication with the gas venting outlet. Gas entrained in the fluid introduced into the housing is separated from the liquid by the hydrophilic fibers, which are impermeable to gas when wetted. The gas is vented from the housing by passing through the hydrophobic fibers, which are relatively impermeable to liquid, thus preventing the collection of gas on the surfaces of the hydrophilic fibers which would reduce the fibers' filtering ability. The gas passes from the hydrophobic fibers out of the housing through the gas venting outlet.

The hollow fibers herein may be two u-shaped bundles, one bundle hydrophilic and one hydrophobic, with the bundle of hydrophobic fibers adjacent to and in substantially side-by-side relation to the bundle of hydrophilic fibers. Use of u-shaped fibers has the advantage of minimizing manufacturing time and cost. One or both bundles of the fibers herein may extend substantially the full length of the interior chamber, thus providing greater filtering and venting surface.

The bundle of hydrophilic fibers of the present invention may be substantially aligned between the fluid inlet and the liquid outlet of the filter housing, with the open ends of the fibers secured by potting compound in an aperture of a potting collar, and

in communication with the liquid outlet. The open ends of the hydrophobic fibers herein may be secured into another aperture of the potting collar so as to be in communication with the gas venting outlet.

The hydrophilic fibers of the present invention are preferably naturally hydrophilic and non-chemical secreting, and there are preferably about twice as many hydrophilic fibers as hydrophobic fibers to provide a large filtering surface area for adequate liquid flow rates.

In an alternative embodiment, the housing may be of a generally elongated and tubular shape, defining a fluid inlet at the upper end. The gas venting outlet may be a lateral aperture located proximal to the lower end of the housing. The open ends of the hydrophobic fibers may be secured within the gas venting outlet with the ends opening to the exterior of the housing and spaced from the ends of the hydrophilic fibers. The hydrophilic fibers may be positioned in a substantially side by side relationship with the hydrophobic fibers with the open ends of the hydrophilic fibers in communication with the open lower end of the housing.

A cap having a liquid outlet may be secured to the open lower end of the housing so as to seal the lower end of the housing and overlie and protect, without blocking, the gas venting aperture.

The filter of an alternative embodiment may be manufactured from a one-piece housing having a branch arm extending from the side of the housing proximal to the open lower end of the housing. The hydrophobic fibers are inserted into the interior of the housing through the branch arm and extend substantially the entire length of the interior housing. The hydrophilic fibers are inserted into the housing through the open lower end of the housing and extend substantially the entire length of the interior housing. The housing is then clamped circumferentially adjacent the juncture of the branch arm and the lower end until both bundles of

fibers are tightly enclosed within the housing. Potting compound is then injected into the housing through the open end or branch arm, preferably the branch arm, thereby sealing the fibers together at the point above the clamp. After the potting compound has cured, the clamp is removed and the branch arm is cut from the housing at the base of the branch arm, thereby exposing the open ends of the hydrophobic fibers to the ambient atmosphere. A cap, having a liquid outlet port is sealingly placed over the open lower end of the housing so that the open ends of the hydrophilic fibers are in communication with the liquid outlet tube of the cap. The cap also overlies the gas venting aperture but is spaced therefrom to define an annular gas venting passageway between the interior sidewall of the cap and the exterior surface of the housing.

Additional features and advantages of the present invention will be apparent from the detailed description of the illustrated embodiments depicted in the drawings.

DESCRIPTION OF DRAWINGS

Figure 1 is an exploded perspective view of the preferred filter of the present invention.

Figure 2 is a bottom plan view of the cap employed in filter of Figure 1.

Figure 3 is a side view of the cap employed in the filter of Figure 1.

Figure 4 is a top plan view of the cap of Figure 4.

Figure 5 is a side elevational view of the filter of Figure 1.

Figure 6 is a side elevational view of the filter of Figure 1 showing the fibers potted in the collar.

Figure 7 is an exploded perspective view, partially broken away, of an alternative filter housing and cap of the present invention.

Figure 8 is a series of perspective views, partially broken away, depicting the manufacture of the alternative embodiment of the present invention depicted in Figure 9.

Figure 9 is a vertical cross-sectional view of an alternative embodiment of the present invention.

Figure 10 is a vertical cross-sectional view of a second alternative embodiment of this invention.

Figure 11 is a cross-sectional view of the second alternative embodiment taken along line 11-11 of Figure 10.

Figure 12 is a cross-sectional view of the second alternative embodiment of this invention taken along line 12-12 of Figure 10.

DETAILED DESCRIPTION OF THE DRAWINGS

Turning now to a detailed description of the present invention as shown in its preferred and alternative embodiments in the attached drawings. Referring to Figure 1, the present invention is generally embodied in a filter unit, generally at 8, which may be an integral part of an overall medical fluid administration set for administering parenteral solutions and the like to patients or, alternatively, as an add-on to a separate administration set.

In the preferred filter unit, the present invention is embodied in a housing made of three molded plastic pieces. These are an upper housing 10 defining a elongated interior chamber 12, a potting collar 14 and a lower end cap 16. The upper housing 10 is generally elongated and oval in cross-sectional shape. The housing 10 has a closed upper end 18 and an open lower end 20.

The upper housing 10 may be constructed from any material which is compatible with the fluid being filtered, but the material is preferably clear, so that the liquid within the filter may be observed. For filtering parenteral solutions, the housing 10 is preferably made of clear, rigid, ABS, PVC, or methyl-acrylic type plastic, such as that available under the trademark PLEXIGLAS from the Rohm and Haas Company of Philadelphia, Pennsylvania, USA. This material is relatively inexpensive and easy to mold.

The potting collar 14 is also of one-piece, molded construction having a generally oval cross-sectional shape. It may be constructed from the same material as the upper housing and may be either clear or opaque. Disposed within the potting collar are two cylindrical ports or apertures 22 and 24 in substantially side-by-side relation. The collar is sealingly joined, as by solvent or sonic bonding, to the lower open end of the upper housing 10 so that the collar's apertures are in direct communication with the interior

chamber 12 of the housing.

The cap 16 is of one-piece, molded construction and may also be constructed of the same material as the upper housing 10 and the potting collar 14. The cap 16 has a base 26 which has a generally oval shape, a gas outlet port 28 and a generally cylindrical liquid outlet tube 30 in substantially side-by-side relationship to the gas outlet. The cap is sealingly joined to and covers the base of the potting collar 14 so that the gas outlet port 28 and the liquid outlet tube 30 are substantially aligned with the two apertures 22 and 24, respectively, of the potting collar 14. As such, the gas outlet port 28 and the liquid outlet tube 30 are in communication, through the apertures of the potting collar 14 and the interior of the hollow fibers, with the interior chamber 12 of the housing 10.

For permitting flow of fluid into the housing, an inlet port tube 32 is provided at the upper end 18 of the housing 10. In the preferred embodiment, the fluid inlet tube 32 is located to one side of the upper end 18 of the housing and is generally aligned with the liquid outlet tube 30.

Disposed within the interior chamber of the upper housing are two bundles or sets of open-ended hollow fibers, 34 and 36. One set of the fibers 34 is constructed of material of a hydrophilic (water attracting) nature and the other set of fibers 36 is constructed of material of a hydrophobic nature (water repelling). The sets of fibers are positioned generally side-by-side within the interior chamber 12. In the preferred embodiment, the fibers are arranged in a U-configuration and having their open ends positioned at the lower end 20 of the interior chamber 12. As an alternative structure, the fibers may be straight having closed ends opposite the open ends of the fibers. However, this embodiment involves the additional step of sealing closed one end of each fiber. In the preferred embodiment, there are approximately twice as many

hydrophilic fibers as hydrophobic fibers.

In the preferred embodiment the hydrophilic fibers 34 are non-chemical secreting and constructed of a naturally hydrophilic material such as mixed esters of cellulose, or nylon, which is compatible with the housing material and aqueous parenteral solutions. The hydrophilic fibers have an average pore size ranging from about 0.1 to 0.45 microns, and preferably about 0.22 microns to remove bacteria from the liquid being filtered. Such fibers are wetted by water and resistant to the transmission of gas therethrough, so long as the gas pressure is below the bubble point of the material of the fibers. The bubble point generally describes the differential pressure across the membrane at which gas will be forced through the wetted fiber membrane, and, for the preferred material described above, is about 40-60 PSIA.

A surfactant may be applied to the surfaces of the hydrophilic fibers 34 to facilitate the flow of aqueous liquid therethrough. For example, a mixture of monoesters of sorbitance with capric, lauric, myristic, palmitic, and/or oleic acids may be used.

The hydrophilic fibers 34 of the preferred embodiment extend the entire length of the interior chamber of the housing 10 for greater filtering capacity, and are substantially aligned between the fluid inlet tube 32 and the liquid outlet tube 30. When fluid is introduced into the housing through the fluid inlet tube 32, the liquid permeates the hydrophilic fibers and is discharged through the liquid outlet tube 30.

The ends of the hydrophilic fibers are open and substantially disposed and fastened within the aperture of the potting collar that is in communication with the liquid outlet tube. The fastening substance is in the form of a potting resin, such as adhesive or urethane resin, which sealingly joins the open ends of the hydrophilic fibers together and secures them within

potting collar aperture with the open ends opening to the liquid outlet tube 30.

The second set of fibers 36 is made of material of a hydrophobic nature. In the preferred embodiment, the set of hydrophobic fibers 36 is in side-by-side, substantially parallel relationship to the set of hydrophilic fibers 34 and extends substantially the entire length of the interior chamber of the housing. Thus, gas entrained within the chamber will come into contact with at least one hydrophobic fiber and pass through the fiber and out of the chamber through the gas outlet port, thus rendering the filter substantially position insensitive. The ends of the hydrophobic fibers are open and positioned at the lower end of the interior housing and are secured by the potting resin in the second aperture of the potting collar. As such, the ends are open to and in communication with the gas outlet port. When fluid is introduced into the housing through the fluid inlet tube, gas entrained in the fluid is separated therefrom by the hydrophilic fibers, permeates the hydrophobic fibers and is discharged from the open ends of the fibers and out the gas outlet port.

An alternative embodiment as shown in Figures 7-9 is a filter according to the present invention, including an upper housing 38 defining an interior chamber 40, and a liquid outlet cap 42. As in the preferred embodiment, the housing and the cap of this alternative embodiment is preferably molded from a material which is compatible with the fluid to be filtered. The upper housing 38 is of a generally tubular shape having a tapered open upper end 44 defining a fluid inlet port 46, and an open lower end 48.

As shown in Figure 7, the housing 38 is constructed of one-piece molded plastic having the general shape as described above, and having an open-ended branch arm 50 extending from the side of the lower

end 48 of the housing 38 at an angle acute to the side of the housing. The interior of the branch arm 50 opens to the interior chamber 40 of the housing 38.

Referring to Figure 9, disposed within the housing are two bundles of substantially adjacent hollow fibers 52 and 54. One bundle 52 of hollow fibers is of a hydrophilic nature, the other bundle 54 is of a hydrophobic nature. The fibers may extend substantially the entire length of the interior housing and may be either u-shaped with open ends or straight with one open end and one closed or sealed end.

Figure 8 shows the various stages of manufacture of this embodiment of the present invention. As shown in Figure 8a, the hydrophobic fibers 54 are positioned within the interior chamber 40 of the housing. The closed ends 56 of the hydrophobic fibers are located in the region of the tapered upper end 44 of the housing 38. The lower portion of the hydrophobic fibers 54 extend into the branch arm 50 of the housing with the closed ends of fibers sticking out of the housing.

As shown in Figure 8b, the hydrophilic fibers are positioned in a substantially side-by-side relationship to the hydrophobic fibers also with their closed ends located in the tapered upper end of the housing. The open ends of the hydrophilic fibers are located at the open lower end of the housing, and away from the open ends of the hydrophobic fibers.

As shown in Figure 8c, the two sets of fibers are encased in potting compound from a point above the juncture of the branch arm and the open lower end of the housing. Preferably this occurs while pressure is being applied circumferentially at the juncture so that the fibers are circumferentially engaged by the interior surface of the housing. Potting compound is injected into the housing through the open end or the branch arm thereby sealing the fibers together above the clamp. After the fibers have been potted at this juncture, the

branch arm 50 of the housing, as shown in Figure 8d, is then cut off from the housing creating a lateral aperture defining a gas vent 58 exposing the open ends of the hydrophobic fibers to the outside of the filter. When fluid is introduced into the interior chamber of the housing, gas entrained within the fluid passes through the hydrophobic fibers and out of the open ends of the fibers through the lateral aperture.

The liquid outlet cap 42 is, in this embodiment, generally cylindrical and includes a liquid outlet port 60. As shown in Figure 8e, after the branch arm 50 has been cut away from the housing, the cap 42 is secured over the open lower end of the housing. The cap extends to the uppermost portion of the gas venting outlet so as to overlie and protect the outlet. The inside diameter of the cap is sufficiently larger than the housing to define an annular venting gap or passageway between the outside of the housing and the inside surface of the cap.

As illustrated in Figure 8f, the open ends of the hydrophilic filters are in communication with the liquid outlet port of the cap. Liquid is introduced into the housing, in this illustration, through a tube, and passes through the hydrophilic fibers and out of the housing through the liquid outlet port into another tube or the like. Gas entrained in the liquid passes through the hydrophobic fibers and out the annular gap into the atmosphere.

Another alternative embodiment is shown in Figures 10-12. As best seen in Figure 10, the filter of this embodiment includes a housing 62 defining an interior chamber 64, and a cap 66. As in the preferred embodiment, the housing and cap of this alternative embodiment may be molded from plastic or other material which is compatible with the fluid to be filtered. The housing 62 is generally cylindrical and has an upper end 68 which includes a substantial tapered fluid inlet port 70. The housing 62 also includes a lower end portion

72.

Two sets of hollow fibers, 74 and 76, are positioned within the interior chamber 64 of the housing 62 and run substantially the entire length of the interior chamber 64. As in the previous embodiments, the fibers may be either U-shaped or straight; and one set of fibers is hydrophilic 74 and the other set is hydrophobic 76. As best seen in Fig. 11, the hydrophobic fibers 76 are positioned generally in three bundles along the side of the interior chamber 64, and preferably positioned within axially-extending recesses 78 defined in the interior wall of the chamber 64. The hydrophilic fibers 74 are positioned in a side-by-side relationship to the hydrophobic fibers. The ends of the two sets of fibers 74 and 76 are disposed within the open lower end 72 of the housing and are encased in potting compound 80, with the ends of the fibers left open, as described above in connection with the preferred embodiment.

The cap 66 is sealingly joined to the open lower end 72 of the housing 62. The cap 66 tapers 82 substantially towards a centrally located cylindrical liquid outlet port 84. One or more gas venting ports 86 may be located to one side of the fluid outlet port 84, in this embodiment. As best seen in Figs. 10 and 12, the cap 66 includes, in this embodiment, a cylindrical inner wall 88, which is circumscribed by the cap's outer wall 66. The inner wall 88 is of sufficient height to seal against the housing 62 and/or against the potting compound 80. In this manner, the inner wall 88 defines a liquid communication passage 90 between the hydrophilic fibers 74 and the liquid outlet port 84. In addition, the inner wall 88 of the cap 66 defines an annular gas venting chamber 92 which provides fluid communication between the hydrophobic fibers and the gas venting port 86.

Although the present invention has been described with reference to specific preferred and

ernative embodiments, the pe of the present invention is not limited to those particular embodiments but defined by the appended claims.

What is claimed:

1. A gas separating and venting filter comprising:

a housing having walls defining an interior chamber;

means defining a fluid inlet into said interior chamber;

means defining a liquid outlet from said interior chamber;

means defining a gas outlet from said interior chamber;

a plurality of hollow microporous fibers of a hydrophilic nature disposed within said interior chamber, with the interior of said hollow fibers being in communication with said liquid outlet; and

a plurality of microporous hollow fibers of a hydrophobic nature disposed within said interior chamber, with the interior of said hollow fibers being in communication with said gas outlet.

2. The filter of Claim 1 wherein at least a portion of said plurality of hydrophilic fibers extends a substantial distance into said chamber.

3. The filter of Claim 2 wherein said plurality of hydrophobic fibers is substantially adjacent and in side-by-side relationship to said plurality of hydrophilic fibers.

4. The filter of Claim 1 wherein said plurality of hydrophobic fibers extends substantially the full length of said interior chamber.

5. The filter of Claim 1 wherein said hydrophobic and hydrophilic fibers are arranged in a u-shape.

6. The filter of Claim 1 wherein said hydrophilic fibers are naturally hydrophilic and

substantially non-chemical secreting.

7. The filter of Claim 1 wherein there are more hydrophilic fibers than hydrophobic fibers.

8. A gas separating and venting filter comprising:

a housing defining an elongated interior chamber, said housing having an open lower end and a closed upper end;

a fluid inlet tube located on the upper end of said housing, said inlet tube being in communication with said interior chamber;

a potting collar sealingly joined to said open lower end of said housing, said collar having a first and second aperture, said apertures being in communication with said interior chamber, and said first aperture substantially aligned with said fluid inlet tube;

a cap sealingly joined to said collar, said cap having a liquid outlet tube and a gas venting aperture, said liquid outlet tube in communication with said first aperture, and said gas venting aperture in communication with said second aperture;

a plurality of u-shaped open-ended microporous, naturally hydrophilic and substantially nonchemical secreting hollow fibers disposed within said interior chamber, said plurality of hydrophilic fibers extending substantially the full length of said interior chamber and having at least a portion generally in alignment with said fluid inlet tube and said liquid outlet tube, said open ends of said hydrophilic fibers

being sealingly disposed within said first aperture of said potting collar, with said open ends remaining open and in communication with said liquid outlet tube; and

a plurality of u-shaped open-ended microporous hydrophobic fibers disposed within said interior chamber and extending substantially the entire length of said interior chamber, said plurality of hydrophobic fibers being substantially adjacent and in side-by-side relationship to said plurality of hydrophilic fibers, said open ends of said hydrophobic fibers sealingly disposed within said second aperture of said potting collar, with said open ends remaining open, and being in communication with said gas venting outlet.

9. The filter of Claim 8 wherein said housing is substantially of an oval cross sectional shape.

10. The filter of Claim 8 wherein said housing is transparent.

11. The filter of Claim 8 wherein there are approximately twice as many of said hydrophilic fibers as hydrophobic fibers.

12. A gas separating and venting filter comprising:

a tubular housing defining an elongated interior chamber, said housing having a tapered open upper end and an open lower end;

a fluid inlet port located at said tapered upper end, said fluid inlet port being in communication with said interior chamber;

a lateral gas venting aperture

located proximal at the lower end of said housing;

a liquid outlet cap having a liquid outlet port sealingly joined to said open lower end of said housing, said liquid outlet port being in communication with said interior chamber, said cap extending sufficiently along said housing to overlie said gas venting aperture and being spaced therefrom to permit venting of gas to the ambient atmosphere;

a plurality of microporous, naturally hydrophilic and substantially nonchemical secreting hollow fibers disposed within said interior chamber, said plurality of hydrophilic fibers each having at least one open end and extending substantially the full length of said interior chamber, said open ends of said hydrophilic fibers being sealingly disposed within said open lower end of said housing, with said open ends remaining open and in communication with said liquid outlet port; and

a plurality of microporous hydrophobic fibers each having at least one open end disposed within said interior chamber and extending substantially the entire length of said interior chamber, said plurality of hydrophobic fibers being in a substantially adjacent and parallel relationship to said plurality of hydrophilic fibers, said open ends of said hydrophobic fibers sealingly disposed within said lateral gas venting aperture, with said open ends remaining open, and being in communication with said gas venting

aperture.

13. The filter of Claim 12 wherein said housing is substantially of a cylindrical cross sectional shape.

14. The filter of Claim 12 wherein said housing is transparent.

15. The filter of Claim 12 wherein there are approximately twice as many of said hydrophilic fibers as hydrophobic fibers.

16. A method of manufacturing a filter comprising:

providing a filter housing, said housing having a fluid inlet port, an open lower end and a branch arm extending laterally from said housing proximal said lower end of said housing;

inserting hydrophilic fibers into said interior chamber of said housing through said open lower end;

inserting hydrophobic fibers into the housing through said branch arm of said housing, wherein at least a portion of said hydrophobic fibers are substantially adjacent to and parallel to said hydrophilic fibers;

applying pressure circumferentially to the housing adjacent the juncture where the branch arm meets the housing until the fibers are circumferentially engaged by the interior surface of said housing;

inserting potting compound into the housing through the open lower end or the branch arm to form a integral seal between the fibers;

cutting the branch arm from the housing thereby opening the ends of the hydrophobic fibers to the exterior of the

housing; and

securing a cap having a liquid outlet port over said open lower end of said housing so that the open ends of the hydrophilic fibers are in communication with the liquid outlet port, said cap being of sufficient diameter to define an annular venting passageway between the outside of the housing and the inside surface of the cap while overlying and protecting the gas venting aperture.

17. A gas separating and venting filter comprising:

a housing defining an elongated interior chamber, said housing having an open lower end and an upper end tapering towards a centrally located fluid inlet port; said fluid inlet port being in fluid communication with said interior chamber;

a plurality of microporous hydrophilic fibers disposed within said interior chamber, said plurality of fibers each having one open end and extending substantially the full length of the said interior chamber, said open ends of said hydrophilic fibers being sealing disposed within said open lower end of said housing;

a plurality of microporous hydrophobic hollow fibers disposed adjacent to the sides of said interior chamber, said plurality of hydrophobic fibers having at least one open end and extending substantially the full length of said longitudinal recesses, said open ends of said hydrophobic fibers being sealing disposed at said open lower end

of said housing and separated from said open ends of said hydrophilic fibers; and

an outlet cap, said cap including a cylindrical inner wall, said wall defining a passage disposed between said cap and said wall, said passage having at least one gas venting aperture, said passage and gas venting aperture being in communication with said hydrophobic fibers, and said liquid outlet port being in communication with said hydrophilic fibers and in substantial alignment with said fluid inlet port.

18. The filter of Claim 17 wherein said interior chamber is substantially circular.

19. The filter of Claim 17 wherein said hydrophobic hollow fibers are disposed within at least one longitudinal recess within said interior chamber.

20. The filter of Claim 17 wherein said hydrophilic fibers are arranged in a u-shape.

21. The filter of Claim 17 wherein said hydrophilic fibers are naturally hydrophilic and substantially non-chemical secreting.

Fig. 1

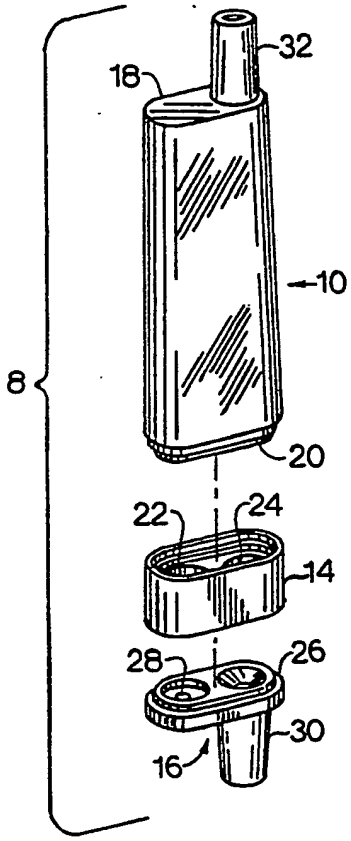


Fig. 2

Fig. 3

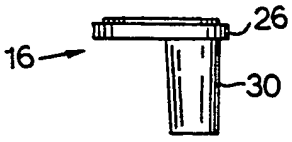


Fig. 4

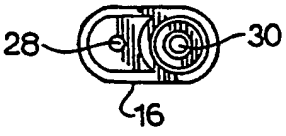


Fig. 5

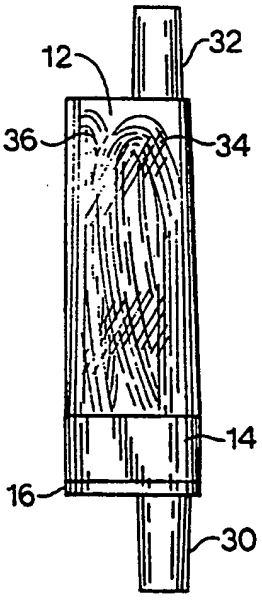
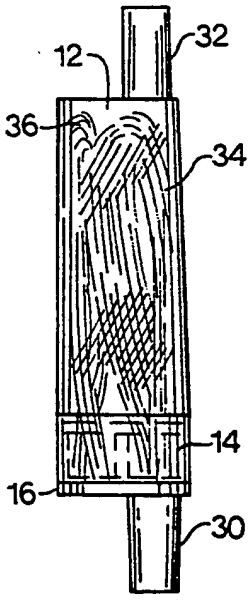


Fig. 6



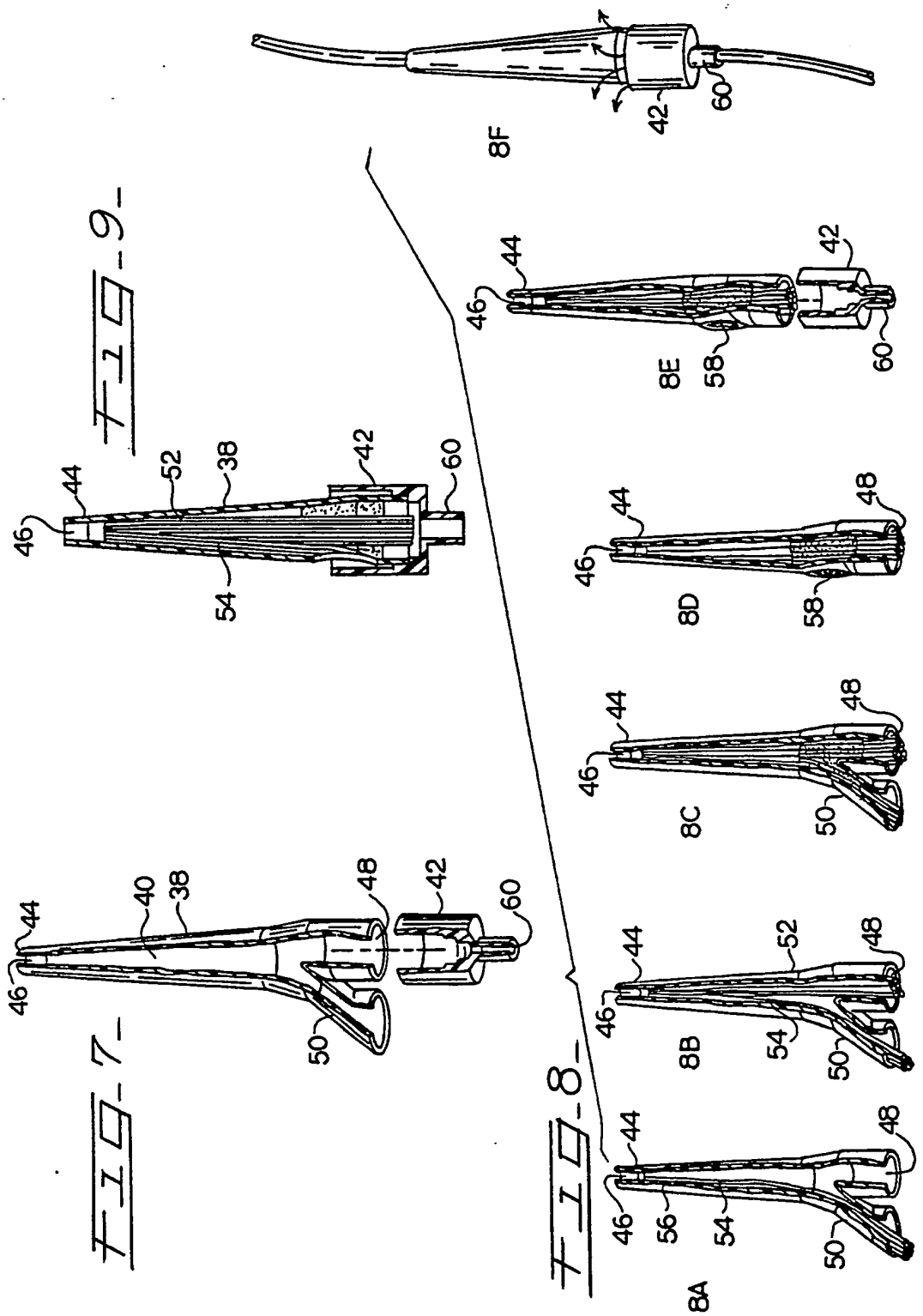


FIG-9
FIG-7
FIG-8
8F
8E
8D
8C
8B
8A
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Fig. 10

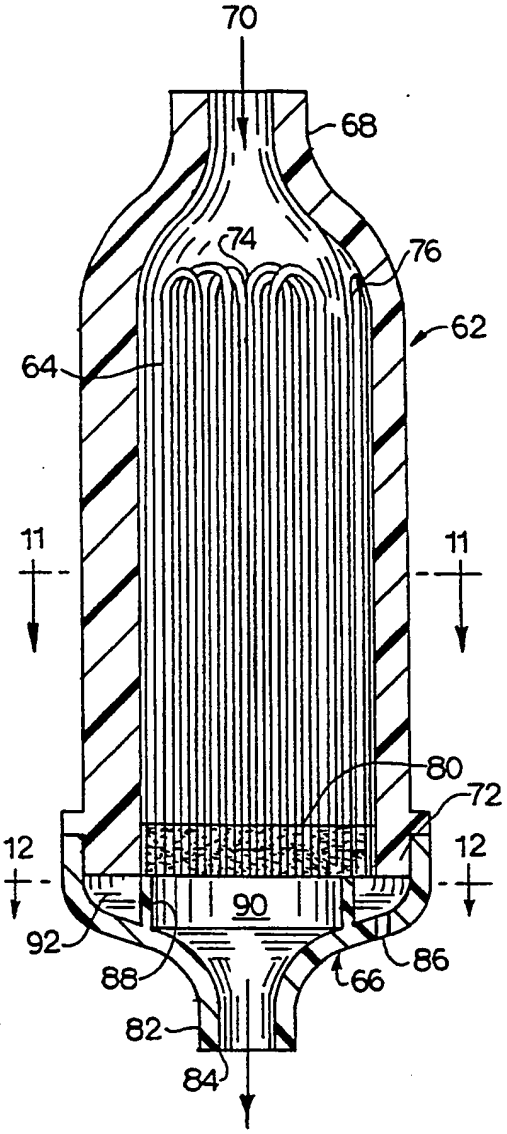


Fig. 11

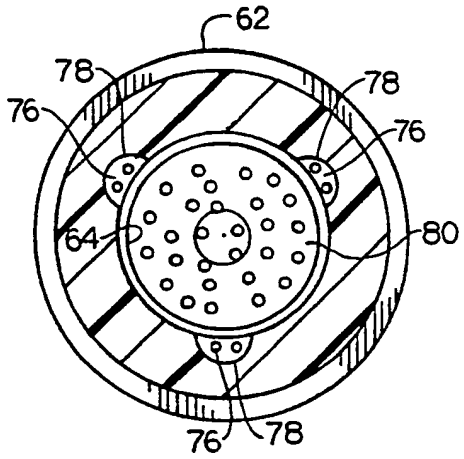
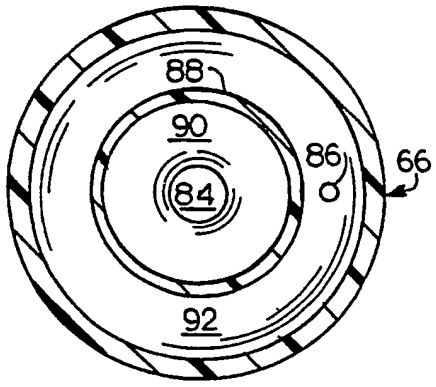


Fig. 12



INTERNATIONAL SEARCH REPO[redacted]

International Application PCT/US 90/01820.

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: B 01 D 19/00, B 01 D 63/04, // A 61 M 5/38

II. FIELDS SEARCHED

Minimum Documentation Searched [7]	
Classification System	Classification Symbols
IPC[5]	B 01 D, A 61 M

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	EP, A, 0254100 (AKZO N.V.) 27 January 1988 see abstract; claims 1-3,7-10,12-15; column 2, lines 4-53; column 3, lines 47-56; column 6, lines 18-31; column 8, line 44 - column 10, line 9; figures 8,9	1-11,17-21
A	--	12-16
X	WO, A, 87/02906 (MICROGON INC.) 21 May 1987 see abstract; claims 1,2; page 2, lines 10-16,28-32; page 3, line 32 - page 6, line 26	1-7
A	--	8-21
A	EP, A, 0207379 (MITSUBISHI RAYON) 7 January 1987 see abstract; claims 1-3,5; figures 1,2	12,13,16
	-- ./.	

* Special categories of cited documents: [14]

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
16th July 1990	07.08.90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	R.J. Eernisse

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, 11 with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US, A, 4636307 (MITSUBISHI RAYON) 13 January 1987 see abstract; figures 1,2 cited in the application & EP, A, 0138060	1-7

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. US 9001820
SA 36143

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 02/08/90
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		JP-A- 63073971	04-04-88
		US-A- 4828587	09-05-89
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		AU-A- 6724787	02-06-87
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		US-A- 4668401	26-05-87
US-A- 4636307	13-01-87	CA-A- 1245567	29-11-88
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